lines indicated by the modern genetical theory of evolution, which while admittedly imperfect has already given an intelligible interpretation of so much that was formerly mysterious, than through a purely hypothetical principle, of the nature of whose operation we have no clear idea at all. Yet these speculations are no more than an attempt to find a solution of a difficulty, which is certainly a real one, and which modern genetics has not yet fully met.

Many biologists have confessed, and still more have felt in private searchings of heart, that it is, if not incredible, at least extremely hard to believe that the perfection of co-ordination and adjustment of the parts of complex organs and of different organs with one another can have been achieved through the selection of merely fortuitous variations or mutations, call them what you will. That natural selection is an agency of prime importance in pruning inadaptive branches may be considered certain. But "inadaptive" is here only a relative term. In using it we are sometimes apt to forget the amazing perfection of organization which the individual organism of even a so-called 'inadaptive type' must possess in order to exist at all. Even the 'worst made' animal is something of a miracle. Natural selection may determine what lines survive, but can it account for the complexity, the co-ordination, the precision of organization which both the 'adaptive' and the 'inadaptive' share in virtue of the fact that they are living creatures? Is selection of merely random changes sufficient to account for the whole of animal organization without some further directive influence, not vitalistic—or Lamarckian—but not yet made clear by research up to date? Such misgivings are perhaps unorthodox in zoology, but others besides palæontologists have felt them.

It may be that the recent contributions of Fisher, Haldane, and others to the theory of natural selection are pointing the way to a solution of the central problem of biology along essentially Darwinian lines without the aid of any new principle. It must be left to the future to decide whether Professor Osborn's theoretical conclusions have any adequate basis, but even if the result is unfavourable to them this cannot detract from the value of the encyclopædic wealth of facts which his monograph contains concerning the evolution of a remarkable group of animals, which must always render it a monument of research and a real landmark in the history of the science with which it deals.

B. W. TUCKER.

PHYSIOLOGY

Huxley, Julian S., M.A. *Problems of Relative Growth.* London, 1932. Methuen. Pp. xix+276. Price 12s. 6d.

THE study of growth, though of outstanding importance, has lagged behind that of most other biological phenomena. In many of the older text-books the size of an organism was treated as an almost accidental circumstance of quite limited significance, and certainly no indication was given that it has a direct bearing upon form. The recognition of growth as a factor playing an important part in moulding the structure of an animal, instead of a mere process of magnification as it were, is largely due to the work of D'Arcy Thompson (1917),* who collected and analysed much evidence on this subject. There has, however, accumulated a mass of data concerned with the relative growth of parts, the bulk of which has remained scattered throughout biological literature. It is this which Professor Huxley has brought together in the present volume. He has amplified it with his own observations and reinterpreted those of others, coordinating the whole in a most successful manner. His treatment of the subject throws an entirely new light upon a variety of well-known problems, and his discussion of these will be found highly interesting and suggestive.

The fundamental proposition upon which the book rests is that, in an extremely wide range of instances, the growth of the parts

* Thompson, D'Arcy W. (1917): *Growth and Form.* Cambridge University Press.

of an organism can be expressed with considerable accuracy by a simple empirical formula. That is to say: if y represents the size of a structure, for example a limb, and x that of the remainder of the body, then the relation of limb to body for any given size can be expressed by the equation $y=bx^k$, where b is a constant (denoting the value of y when $x=1$). It is evident that k here represents the relative increase of y with respect to x, and Huxley has brought forward extensive data, ranging over very diverse groups of organisms, to show that in any given instance this term remains constant over a wide range of size.

Now when $k=1$, organ and body increase together at the same absolute rate. But Huxley has demonstrated that this is exceptional. More often the organ increases disproportionately, growth then being *relatively* constant or *heterogonic*. Thus a limb may reach extravagant proportions if the value of k is high ($k>1$), or gradually become vestigial if it is low ($k<1$). In these circumstances the thing which is constant is not its proportion as measured by percentage of the whole, but the rate of its growth relative to the body; in fact, the value of k.

Huxley has further shown that heterogonic growth is not a discontinuous phenomenon. A heterogonic organ is itself pervaded by a growth-gradient culminating in a point where relative growth is most extreme in either the + or the − direction, as the case may be. Working outwards from the body to such a point, the value of k steadily alters. It is evident, therefore, that heterogonic growth may be responsible for gross changes in shape as well as in total proportion. He further brings forward evidence to show that gradients such as these are not isolated, but form part of a general system of growth-gradients permeating the whole body.

These then represent the main laws which it has been possible to deduce from a study of relative growth. Certain facts have been collected which throw some light on the way in which they operate. For Huxley has found that structures which are shed at intervals, such as the antlers of deer, conform to the heterogony relation in the maximum size to which they attain at each growth-period. Further, a regenerating limb will grow very rapidly until it reaches its normal relative size, after which it settles down to grow at the relative rate characteristic of the limb in question. It would appear, therefore, that heterogony is concerned rather with the limitation than the speed of growth; in fact, it expresses a limit to which an organ can attain relative to the body. The sections of the book in which this view is developed will be found of particular interest.

The last chapter is devoted to a consideration of the bearing of these discoveries upon other branches of biology. This discussion has been skilfully handled, and clearly brings out the utility of the heterogony concept in the interpretation of biological phenomena.

It is evident that systematists must henceforth recognize that the percentage size of parts is no guide to relationship, and that the general proportions of an organ itself may alter automatically with the size of the animal. Detailed shape, however, appears to be controlled independently by the genetic constitution.

From the physiological point of view, growth-gradients allow mutation and selection to affect a number of parts in a correlative way. Huxley also stresses the fact that genetic factors are known which control the *rate* of developmental processes in the body. Mutation and selection, therefore, can operate directly to influence heterogony, and the importance of such rate-factors becomes even more clearly evident.

It is perhaps in its bearing upon evolution that the greatest interest of heterogony centres. For example, an organ with a high growth-rate will limit the extreme absolute size to which a species can attain, and may easily become a grave disadvantage if conditions change. Gradual increase in body-size during evolution, in itself advantageous, combined with heterogony will necessarily involve automatic changes in proportion which may be of no adaptive significance. Such progressive changes in structure over long periods of time, which have so often been invoked as evidence of orthogenesis, can now be explained in this way. Of these the development of horns in different lines of Titanothere evolution is a well-known example and, in our own country, it appears possible that changes in the proportions of British skulls may be interpreted along similar lines.

The book is profusely illustrated and a large number of the figures are original. It is skilfully written and the interest is never allowed to flag. Without doubt it represents a contribution of great importance to the study of variation, of man as well as of other animals, and as such will be read with profit by biologists and eugenists alike.

E. B. F.